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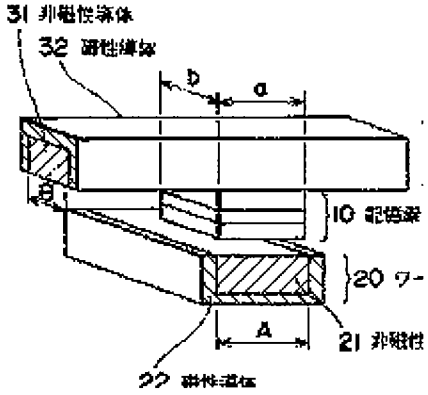
(54)【発明の名称】　磁気メモリ装置

(57)【要約】
【課題】　記憶素子の保磁力を小さくしなくても、従来よりも小さな書き込み電流での情報記録が可能となる磁気メモリ装置を提供する。
【解決手段】　磁気抵抗効果型の記憶素子１０と、その記憶素子１０に近接して配された書き込み線２０、３０とを備え、書き込み線２０、３０が発生する電流磁界により記憶素子１０の磁化方向を反転させるように構成された磁気メモリ装置において、書き込み線２０、３０を、非磁性導体２１、３１と、高透磁率を持つ磁性導体



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【特許請求の範囲】

【請求項１】　磁気抵抗効果型の記憶素子と、当該記憶素子に近接して配された書き込み線とを備え、前記書き込み線が発生する電流磁界により前記記憶素子の磁化方向を反転させるように構成された磁気メモリ装置において、

前記書き込み線は、非磁性導体と高透磁率を持つ磁性導体とからなる複合構造を有していることを特徴とする磁気メモリ装置。

【請求項２】　前記書き込み線を構成する非磁性導体は、前記記憶素子に面して配されていることを特徴とする請求項１記載の磁気メモリ装置。

【請求項３】　前記書き込み線を構成する磁性導体は、当該書き込み線の断面が略方形状に形成されている場合に、前記記憶素子側の面を除く三面を覆うように配されていることを特徴とする請求項２記載の磁気メモリ装置。

【請求項４】　前記記憶素子に面して配された非磁性導体の断面幅が前記記憶素子の素子幅以上の大きさに形成されていることを特徴とする請求項３記載の磁気メモリ装置。

【請求項５】　前記書き込み線を構成する磁性導体は、当該書き込み線の断面が略方形状に形成されている場合に、前記記憶素子側の面に対向する面のみを覆うように配されていることを特徴とする請求項２記載の磁気メモリ装置。

【請求項６】　前記書き込み線を構成する磁性導体は、ニッケル、鉄、コバルト、またはこれらの合金からなるものであることを特徴とする請求項１～５のいずれか１項に記載の磁気メモリ装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、情報を記憶するためのメモリデバイスとして用いられる磁気メモリ装置に関する。

【０００２】

【従来の技術】近年、情報通信機器、特に携帯端末装置等の個人用小型機器の飛躍的な普及に伴い、これを構成するメモリやロジックといったデバイスには、高集積化、高速化、低電力化等、より一層の高性能化が要請さ

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ndom Access Memory）やＳＲＡＭ（S
ss Memory）等の揮発性メモリに比べ
がある。一方、ＦｅＲＡＭにおいて
数が少ないという問題が指摘されて
【０００４】これらの欠点を有さな
して注目されているのが、ＭＲＡＭ
Access Memory）と呼ばれる磁気メモ
えば、Wang et al.,IEEE Trans.Mag
照）。ＭＲＡＭは、巨大磁気抵抗効
esistive；ＧＭＲ）型またはトンネ
nnel Magnetoresistive；ＴＭＲ）型
て情報記憶を行うもので、特に近年
向上により注目を集めるようになっ
【０００５】詳しくは、ＭＲＡＭで
配列された磁気抵抗効果型の記憶素
に、その素子群のうちの特定素子に
に素子群を縦横に縞切るワード書き
込み線とを有しており、その交差領
みにアステロイド特性を利用して選
みを行うように構成されている（例
１１６４９０公報参照）。このよう
は、構造が単純であるため高集積化
磁気抵抗効果型記憶素子における磁
により情報記憶を行うために書き換
る。さらには、アクセス時間につい
ることが予想され、既にナノ秒台で
が確認されている。

【０００６】

【発明が解決しようとする課題】し
Ｍにおいては、記憶素子に情報を記
み電流の大きさが問題となる。すな
報を記憶させる際には、ワード書き
書き込み線が発生する電流磁界によ
向を反転させるが、そのときに大き
要であると、微細化（高密度化）や
げとなってしまう可能性がある。

【０００７】具体的には、従来のＭ
き込み線およびビット書き込み線が
（アルミニウム）等といった半導体
膜状の非磁性導体のみから形成され

磁力を小さくすると、外部からの磁気的な擾乱によって記憶素子での磁化方向が反転してしまい、メモリデバイスとしての信頼性低下を招いてしまうおそれがある。

【０００９】そこで、本発明は、記憶素子の保磁力を小さくしなくても、従来よりも小さな書き込み電流での情報記憶が可能となる磁気メモリ装置を提供することを目的とする。

【００１０】

【課題を解決するための手段】本発明は、上記目的を達成するために案出されたもので、磁気抵抗効果型の記憶素子と、この記憶素子に近接して配された書き込み線とを備え、前記書き込み線が発生する電流磁界により前記記憶素子の磁化方向を反転させるように構成された磁気メモリ装置において、前記書き込み線が、非磁性導体と高透磁率を持つ磁性導体とからなる複合構造を有していることを特徴とするものである。

【００１１】上記構成の磁気メモリ装置によれば、書き込み線の複合構造のうちの磁性導体の部分では磁束が透過するので、書き込み線に電流を与えると、その周囲に均一に分布した状態で磁力線が発生するのではなく、磁性導体ではない非磁性導体の部分に集中して磁力線が発生する。したがって、集中した磁力線により記憶素子の磁化方向を反転させるようにすれば、磁力線が均一に分布する場合よりも小さな電流で磁化方向の反転を行い得るようになる。

【００１２】

【発明の実施の形態】以下、図面に基づき本発明に係る磁気メモリ装置について説明する。

【００１３】〔磁気メモリ装置の概要〕先ず、はじめに、本発明に係る磁気メモリ装置全体の概略構成について説明する。図１は、ＭＲＡＭと呼ばれる磁気メモリ装置の基本的な構成例を示す模式図である。ＭＲＡＭは、マトリクス状に配された複数の磁気抵抗効果型の記憶素子１０を備えている。さらに、これらの記憶素子１０が配された行および列のそれぞれに対応するように、相互に交差するワード書き込み線２０およびビット書き込み線３０が、各記憶素子１０群を縦横に横切るように設けられている。そして、各記憶素子１０は、ワード書き込み線２０とビット書き込み線３０とに上下から挟まれた状態で、かつ、これらの交差領域に位置するように、そ

センスアンプ５２とが設けられてお
記憶素子１０に記憶された情報を検
いる。

【００１５】続いて、このような構
る各記憶素子部分の構成について説
一の記憶素子部分の断面構成の一例
る。それぞれの記憶素子部分では、
に、ゲート領域４２、ソース領域４
域４４からなる電界効果トランジス
さらにその上方に、ワード書き込み
０およびビット書き込み線３０が順
このことからも明らかなように、記
ド書き込み線２０とビット書き込み
おいて、これらの書き込み線２０，
れるように配されている。

【００１６】ここで、記憶素子１０
説明する。ＭＲＡＭでは、記憶素子
材料を利用するものと、ＴＭＲ材料
るが、ここではＴＭＲタイプのもの
る。

【００１７】図４は、ＴＭＲタイプ
用される磁気抵抗効果膜の断面構成
である。ＴＭＲタイプの記憶素子１
（ニッケル）、Ｆｅ（鉄）若しくは
またはこれらの合金といった磁性体
が比較的容易に回転する情報記憶層
書き込み線２０、３０が発生する電
の情報記憶層１１の磁化方向を変化
の書き込み（記録）を行うようにな

【００１８】情報記憶層１１の下方
（アルミニウム）、Ｍｇ（マグネシ
コン）等の酸化層または窒化層等か
トンネルバリア層１２を有しており、
後述する磁化固定層１３との磁気的
に、トンネル電流を流すための役割
【００１９】トンネルバリア層１２
定層１３を有している。磁化固定層
固定層１３ａと第二の磁化固定層１
層からなる。そして、二つの磁性層
には、これらの磁性層１３ａ、１３

ム）等のＭｎ（マンガン）合金、ＣｏやＮｉ酸化物等が使用できる。

【００２１】反強磁性体１５の下方には、例えばＣｏおよびＳｉからなる二重下地層１６を有している。

【００２２】このように構成されたＴＭＲタイプの記憶素子１０では、磁気抵抗効果によるトンネル電流変化を検出して情報を読み出すことになる。ただし、その効果は、情報記憶層１１と磁化固定層１３との相対磁化方向に依存することになる。

【００２３】なお、上述した各層（磁性膜および導体膜）１１，１３～１６は、主に公知のスパッタリング法により形成し、またトンネルバリア層１２は、スパッタリングで形成された金属膜を酸化または窒化させることにより形成すればよい。

【００２４】以上のようなＴＭＲタイプの記憶素子１０を備えたＭＲＡＭでは、その記憶素子がワード書き込み線２０およびビット書き込み線３０の交差領域に配置されているので、これらの二本の書き込み線２０，３０を使用することにより、アステロイド磁化反転特性を利用して、選択的に個々の記憶素子１０に情報を書き込むようになっている。

【００２５】このとき、単一の記憶素子１０における合成磁化は、それに印加された容易軸方向の磁界H_{EA}と困難軸方向の磁界H_{HA}とのベクトル合成によって決まる。ビット書き込み線３０を流れる書き込み電流は、記憶素子１０に容易軸方向の磁界H_{EA}を印加し、ワード書き込み線２０を流れる電流は、記憶素子１０に困難軸方向の磁界H_{HA}を印加する。

【００２６】図５は、ＭＲＡＭにおける記憶素子の磁界応答の一例を示すアステロイド図である。図中のアステロイド曲線は、印加された磁界H_{EA}および磁界H_{HA}による情報記憶層１１の磁化方向の反転しきい値を示している。すなわち、アステロイド曲線の外部に相当する合成磁界ベクトルが発生すると、記憶素子１０に磁界反転が生じる。ただし、アステロイド内部の合成磁界ベクトルは、その電流双安定状態の一方から記憶素子１０の磁界を反転させることはない。また、電流を流しているワード書き込み線２０およびビット書き込み線３０の交差点以外に位置する記憶素子１０に対しても、それぞれの書き込み線２０，３０が単独で発生する磁界が印加され、

【００２８】一般に、従来のＭＲＡＭみ線およびビット書き込み線がＣｕ磁性導体のみから形成されている。

【００２９】これに対して、本実施ＡＭは、図６に示すように、記憶素むる書き込み線２０，３０が、いずたはこれらの合金等の導電性物質か１，３１と、高透磁率を持つ磁性導らなる複合構造を有している。

【００３０】磁性導体２２，３２のはＮｉ，Ｆｅ，Ｃｏまたはこれらを用いればよい。具体的には、パーマー Ｆｅ合金（鉄ニッケル合金）を用る。

【００３１】また、各書き込み線２もその断面が略方形状に形成されて素子１０側の面を除く三面が略コ字３２に被覆されており、記憶素子１性導体２１，３１が露出している。込み線２０，３０同士では、非磁性出面が向き合っており、また磁性導が互いに対称となるように配されてき込み線２０，３０において、非磁記憶素子１０側に露出する部分の断照）は、記憶素子１０の素子幅（図の大きさに形成されている。

【００３２】以上のような各書き込次に述べるようにして形成すればよ上方に位置するビット書き込み線３は、従来と同様に非磁性導体３１のメッキ法等により磁性導体３２の部よって形成することが考えられる。の下方に位置するワード書き込み線えば、成膜プロセス中にトレンチ（後、メッキ法等によりそのトレンチに磁性導体２２を成膜し、さらにそ導体２１で埋めることによって形成る。

【００３３】このような構成の書き用いることで、本実施形態における

生するのではなく、その磁性導体２２，３２での磁束透過によって、非磁性導体２１，３１の部分に集中して磁力線が発生することがわかる。具体的には、数値シミュレーションによると、書き込み線２０，３０の幅と厚さがそれぞれ０．２５μｍである場合．１ｍＡの電流を流すと．非磁性導体２１，３１に面する記憶素子１０の中央部分に発生する磁界の大きさは約１５０ｅとなる。

【００３５】これに対して．図７（ｂ）に示すように、非磁性導体のみで書き込み線を構成した場合には．その周囲に磁力線が均一に分布してしまうので、０．２５μｍの幅および厚さの書き込み線に１ｍＡの電流を流しても．記憶素子１０の中央部分では、約５０ｅ程度の大きさの磁界しか得られない。

【００３６】したがって．本実施形態で説明した複合構造の書き込み線２０，３０を用いれば．従来（磁力線が均一に分布する場合）よりも効率良く書き込み磁界を発生させることができるので．結果として従来よりも小さな電流で記憶素子１０の磁化方向を反転させ得るようになる。

【００３７】このような効果を効率的に得るためには、書き込み線２０，３０に被覆する磁性導体２２，３２の透磁率を、概ね１０以上とすることが望ましい。また、磁性導体２２，３２の被覆厚さは、０．０１μｍ以上とすれば発生磁界増加の効果が得られることが確認されている。

【００３８】また、略方形状の周囲三方を磁性導体２２，３２で被覆した場合には、略コ字状の磁性導体２２，３２の両先端部よりも内側部分（非磁性導体２１，３１の部分）に多くの磁力線が集中する。そのため、非磁性導体２１，３１の断面幅Ａ，Ｂを記憶素子１０の素子幅ａ，ｂ以上の大きさに形成すれば．磁性導体２２，３２の両先端部の間隔よりも記憶素子１０の情報記憶層１１の幅が短くなり、その両先端部に挟まれる形で情報記憶層１１が配置されることになるので、集中して発生した磁力線を効率よく情報記憶層１１に印加することができる。

【００３９】〔第２の実施の形態〕次に、本発明の第２の実施の形態におけるＭＲＡＭ（磁気メモリ装置）の特徴点について説明する。図８は、本発明に係る磁気メモリ装置の他の例の特徴的な要部の構成を示す模式図であ

面のみが、磁性導体２２，３２に被
がって、記憶素子１０側の面および
は．いずれも非磁性導体２１，３１
【００４２】以上のような各書き込
次に述べるようにして形成すればよ
上方に位置するビット書き込み線３
ば．Ｃｕ、Ａｌまたはこれらの合金
３１をスパッタ装置またはＣＶＤ（
osition）装置により成膜し、次いで
りパーマロイからなる磁性導体３２
オンミリングまたは反応性イオンエ
のパターンとすることによって形成
る。一方、記憶素子１０の下方に位
み線２０については、例えばビット
逆に．磁性導体２２、非磁性導体２
とが考えられる。ただし．非磁性導
磁性導体２２、３２の成膜は、上述
メッキ法を適用しても構わない。

【００４３】このような構成の書き
用いることで．本実施形態のＭＲＡ
の実施の形態の場合と同様に、複合
体２２，３２の部分で磁束が透過す
み線の周囲に分布していた磁力線が
導体２２，３２によって収束され、
１が露出している部分に集中して発
したがって、本実施形態で説明した
線２０，３０を用いれば．従来（磁
る場合）よりも効率良く書き込み磁
ができるので．結果として従来より
素子１０の磁化方向を反転させ得る
【００４４】また、本実施形態のＭ
磁性導体２２，３２が記憶素子１０
すなわち一面のみを被覆しているた
態の場合に比べると、磁力線が集中
が．書き込み線２０，３０の両側面
ため．製造上の容易性に優れる。つ
Ｍの製造工程に．磁性導体２２，３
二回追加するだけで、従来よりも書
図れ．非常に実現が容易なものとな
【００４５】なお．上述した第１お

１０との対向面のみを磁性導体２２，３２で被覆した場合をそれぞれ例に挙げて説明したが，本発明はこれに限定されるものではない。例えば，略方形状の書き込み線の両側面のみを磁性導体２２，３２で被覆した場合であっても，その磁性導体２２，３２を磁束が透過し，非磁性導体２１，３１の部分に集中して磁力線が発生するので，書き込み電流の低減が図れるようになる。

【００４７】さらに，第１および第２の実施の形態では，記憶素子１０がＴＭＲ材料を利用するものである場合について説明したが，ＧＭＲ材料を利用したものの場合にも全く同様に適用できるのは勿論である。

【００４８】

【発明の効果】以上に説明したように，本発明の磁気メモリ装置は，書き込み線を非磁性導体と磁性導体とからなる複合構造とすることによって，書き込み線に電流を与えた場合に非磁性導体の部分に集中して磁力線が発生するようになるので，従来よりも小さい書き込み電流で記憶素子への情報書き込みが可能となる。したがって，記憶素子の保磁力を小さくすることなく，書き込み電流の低減が図れるので，結果として書き込み線駆動回路の縮小等による磁気メモリ装置の微細化（高密度化），磁気メモリ装置の低消費電力化，書き込み線のエレクトロン・マイグレーション破断の低減による信頼性向上等の実現が容易となる。

＊【図面の簡単な説明】

【図１】磁気メモリ装置の基本的な
である。

【図２】磁気メモリ装置の概略構成
模式図である。

【図３】磁気メモリ装置を構成する
の断面構成の一例を示す模式図であ

【図４】トンネル磁気抵抗効果型の
される磁気抵抗効果膜の断面構成の
ある。

【図５】磁気メモリ装置における記
一例を示すアステロイド図である。

【図６】本発明に係る磁気メモリ装
要部の構成を示す模式図である。

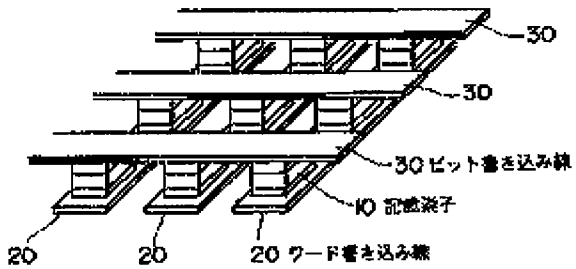
【図７】書き込み線一本分における
レーション結果の具体例を示す説明
本発明に係るシミュレーション結果
従来のシミュレーション結果を示す

【図８】本発明に係る磁気メモリ装
な要部の構成を示す模式図である。

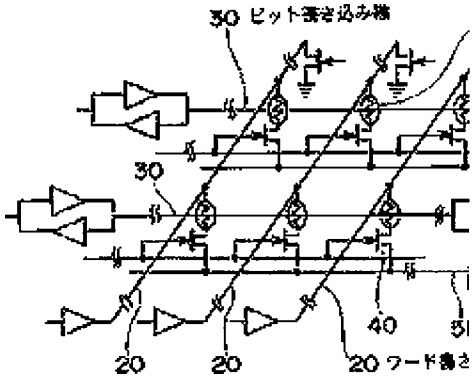
【符号の説明】

１０…記憶素子，２０…ワード書き
性導体，２２…磁性導体，３０…ビ
１…非磁性導体，３２…磁性導体

【図１】



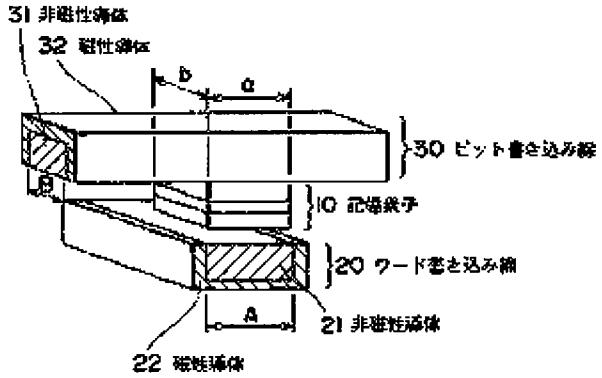
【図２】



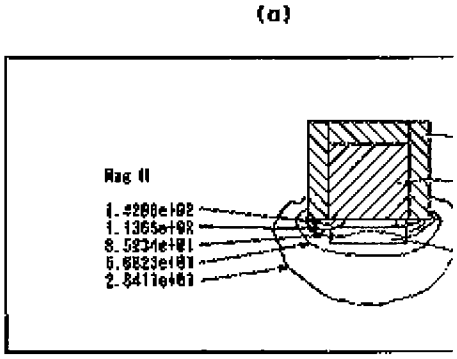
【図３】

【図４】 【図

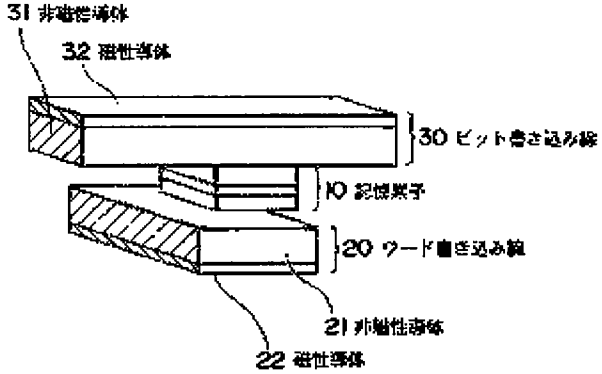
【図６】

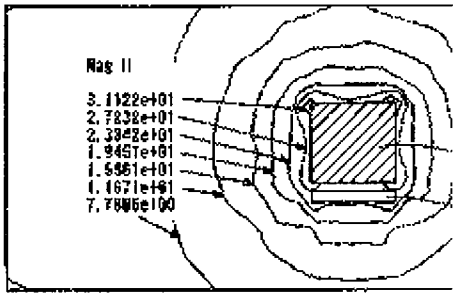


【図７】



【図８】





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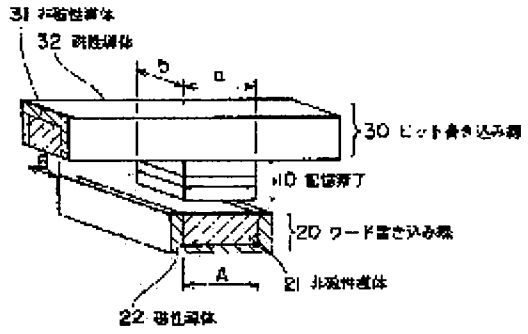
(54) STORAGE MEMORY DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a magnetic memory device which enables the recording of information with a write current smaller than before, without lessening the coercive force of a storage element.

SOLUTION: The magnetic memory device is equipped with a magnetoresistive effect type of storage element 10 and write lines 20 and 30 arranged close to the storage element 10, and is so constituted so to invert the direction of the magnetization of the storage element 10 by the current magnetic filed generated by the write lines 20 and 30. The write lines 20 and 30 are of composite



structure consisting of nonmagnetic conductors 21 and 31 and magnetic conductors 22 and 32 having high permeability.

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
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CLAIMS

[Claim(s)]
[Claim 1] the magnetic memory apparatus constituted so that the magnetization direction of said storage element might be reversed by the current field which was allotted by approaching the storage element of a magneto-resistive effect mold, and the storage element concerned, and which writes in, and is equipped with a line and said write-in line generates -- setting -- said write-in line -- nonmagnetic -- magnetism with a conductor and high permeability -- the magnetic memory apparatus characterized by having the composite construction which consists of a conductor.
[Claim 2] nonmagnetic [which constitutes said write-in line] -- the magnetic memory apparatus according to claim 1 characterized by for a conductor facing said storage element and arranging it.
[Claim 3] the magnetism which constitutes said write-in line -- the third page excluding the field by the side of said storage element when, as for the conductor, the cross section of the write-in line concerned is formed in the shape of an abbreviation rectangle -- a wrap -- the magnetic memory apparatus according to claim 2 characterized by being allotted like.
[Claim 4] nonmagnetic [which was allotted by facing said storage element] -- the magnetic memory apparatus according to claim 3 characterized by forming the cross-section width of face of a conductor in the magnitude more than the component width of face of said storage element.
[Claim 5] the magnetism which constitutes said write-in line -- the field where a conductor counters the field by the side of said storage element when the cross section of the write-in line concerned is formed in the shape of an abbreviation rectangle -- a wrap -- the magnetic memory apparatus according to claim 2 characterized by being allotted like.
[Claim 6] the magnetism which constitutes said write-in line -- a magnetic memory apparatus given in any 1 term of claims 1-5 characterized by a conductor being what consists of nickel, iron, cobalt, or these alloys.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the magnetic memory apparatus used as a memory device for memorizing information.
[0002]
[Description of the Prior Art] In recent years, much more high performance-ization of high integration, improvement in the speed, low electrification, etc. is requested from a device called the memory and logic which constitute this with the fast spread of personal small devices, such as information communication equipment, especially personal digital assistant equipment. Especially the high density and large capacity-ization of nonvolatile memory are becoming still more important as a technique in which a miniaturization essentially replaces a difficult hard disk drive unit and a difficult optical disk unit by existence for moving part (for example, a head seeking device and a disk rolling mechanism).
[0003] The flash memory using the semi-conductor as nonvolatile memory, FeRAM (Ferro electric Random Access Memory) using a ferroelectric, etc. are known widely. However, informational drawing speed is the order of mu second, and a flash memory has the fault that it is late compared with volatile memory, such as DRAM (Dynamic Random Access Memory) and SRAM (Static Random Access Memory). On the other hand, the problem that there are few rewritable counts is pointed out in FeRAM.
[0004] The magnetic memory apparatus called MRAM (Magnetic Random Access Memory) is observed as nonvolatile memory which does not have these faults (for example, Wang et al., IEEE Trans.Magn.33 (1997), 4498 reference). MRAM performs information storage using the storage element of a giant magneto-resistance (Giant Magnetoresistive;GMR) mold or a tunnel magneto-resistive effect (Tunnel Magnetoresistive;TMR) mold, and attracts attention increasingly by improvement in a property of a TMR ingredient in recent years especially.
[0005] In detail, in order to record information on the specific component of the elements, it has the WORD write-in line and the bit write-in line which cross the elements in all directions, and while have the storage element of the magneto-resistive effect mold arranged in the shape of a matrix, it consists of MRAM(s) so that information may be alternatively write only in the component locate in the crossover field using an asteroid property (for example, refer to publication number 10 1 116490 official report). Since MRAM of such a configuration has simple structure, high integration is easy, and a rewritable count is size in order for rotation of the magnetic moment in a magneto-resistive effect mold storage element to perform information storage. Furthermore, it is expected that it is very high-speed also about the access time, and it is checked that it can already operate on a nanosecond base.
[0006]
[Problem(s) to be Solved by the Invention] However, in MRAM, the magnitude of the write-in current at the time of storing information in a storage element poses a problem. That is, although the

magnetization direction of a storage element is reversed by the current field which a WORD write-in line and a bit write-in line generate in case information is stored in a storage element, a write-in big current may be then necessary with hindrance, such as detailed-izing (densification) and low-power-izing.

[0007] nonmagnetic [of the shape of a thin film specifically used usually with semi-conductors / MRAM / conventional / line / a WORD write-in line and / bit write-in /, such as Cu (copper) and aluminum (aluminum),] -- although formed only from a conductor, if coercive force tends to write in the storage element of 20Oe(s) when those line breadth is 0.25 micrometers, for example, it is necessary to write in the big current of about 2mA, and to pass on a line furthermore, the case of for example, a write-in line where a cross-section configuration is an abbreviation rectangle -- the thickness -- line breadth and abbreviation -- the current density in that case will become the same with 3.2x106 A/cm2, and it will become close to the open-circuit threshold value by electron migration.

[0008] To such the present condition, decreasing a write-in current is also considered by making coercive force of a storage element small, for example. However, when coercive force of a storage element is made small, the magnetization direction in a storage element is reversed with the magnetic turbulence from the outside, and there is a possibility of causing the dependability fall as a memory device.

[0009] Then, even if this invention does not make coercive force of a storage element small, it aims at offering the magnetic memory apparatus whose information storage in a write-in current smaller than before becomes possible.

[0010]

[Means for Solving the Problem] the magnetic memory apparatus constituted so that the magnetization direction of said storage element may reverse by the current field which was allotted by this invention having been thought out in order to attain the above-mentioned purpose, and approaching the storage element of a magneto-resistive effect mold, and this storage element, and which writes in, and is equipped with a line and said write-in line generates -- setting -- said write-in line -- nonmagnetic -- magnetism with a conductor and high permeability -- it is characterized by to have the composite construction which consists of a conductor.

[0011] according to the magnetic memory apparatus of the above-mentioned configuration -- the magnetism of the composite constructions of a write-in line -- the condition of having been distributed over the perimeter at homogeneity when the current was given to the write-in line, since magnetic flux penetrated in the part of a conductor -- line of magnetic force -- not generating -- magnetism -- nonmagnetic [which is not a conductor] -- it concentrates on the part of a conductor and line of magnetic force is generated. Therefore, if it is made to reverse the magnetization direction of a storage element with the concentrated line of magnetic force, the magnetization direction can be reversed with a current smaller than the case where line of magnetic force is distributed over homogeneity.

[0012]

[Embodiment of the Invention] Hereafter, the magnetic memory apparatus which starts this invention based on a drawing is explained.

[0013] [Outline of a magnetic memory apparatus] The outline configuration of the magnetic whole memory apparatus concerning this invention is explained first. Drawing 1 is the mimetic diagram showing the fundamental example of a configuration of the magnetic memory apparatus called MRAM. MRAM is equipped with the storage element 10 of two or more magneto-resistive effect molds arranged in the shape of a matrix. Furthermore, the WORD write-in line 20 and the bit write-in line 30 which cross mutually are formed so that each storage element 10 group may be crossed in all directions, so that it may correspond to each of the line on which these storage elements 10 were arranged, and a train. And each is arranged so that each storage element 10 may be in the condition inserted into the WORD write-in line 20 and the bit write-in line 30 from the upper and lower sides and it may be located in these crossover fields.

[0014] Drawing 2 is the mimetic diagram showing the outline configuration of MRAM in a detail further. although it is allotted in MRAM so that the WORD write-in line 20 and the bit write-in line 30 (only henceforth [these are named generically and] "a write-in line") may cross storage element 10 group in all directions -- the crossover field of the lines 20 and 30 write-in [these] -- a storage element 10 -- in addition, the field-effect transistor 40 which connects with each storage element 10 according to an individual is formed. And corresponding to the field-effect transistor 40 of each train, the sense amplifier 52 linked to a sense line 51 and this is formed, and the information memorized by these at the storage element 10 is detected.
[0015] Then, the configuration of each storage element part in MRAM of such a configuration is explained. Drawing 3 is the mimetic diagram showing an example of the cross-section configuration of a single storage element part. In each storage element part, the field-effect transistor 40 which consists of the gate field 42, a source field 43, and a drain field 44 is arranged on the semi-conductor substrate 41, and the WORD write-in line 20, the storage element 10, and the bit write-in line 30 are further arranged in the upper part in order. The storage element 10 is arranged at the crossing of the WORD write-in line 20 and the bit write-in line 30 so that it may be inserted into these write-in lines 20 and 30 from the upper and lower sides, so that clearly also from this.
[0016] Here, the configuration of storage element 10 the very thing is explained. Although there are a thing using a GMR ingredient and a thing using a TMR ingredient as a storage element 10 in MRAM, a TMR type thing is mentioned as an example and explained here.
[0017] Drawing 4 is the mimetic diagram showing an example of the cross-section configuration of the magneto-resistive effect film used as a TMR type storage element. With the TMR type storage element 10, it consists of the magnetic substance, such as nickel (nickel), Fe (iron), Co(es) (cobalt), or these alloys, for example, and has the information storage layer 11 which the magnetization direction rotates comparatively easily, and information is written in by changing the magnetization direction of the information storage layer 11 by the current field which the write-in lines 20 and 30 generate (record).
[0018] Under the information storage layer 11, it has the tunnel barrier layer 12 by the insulator which consists of an oxidizing zone or nitrated cases, such as aluminum (aluminum), Mg (magnesium), and Si (silicon), etc., and while cutting magnetic association with the information storage layer 11 and the magnetization fixed bed 13 mentioned later, the role for passing tunnel current is borne.
[0019] Under the tunnel barrier layer 12, it has the magnetization fixed bed 13. The magnetization fixed bed 13 consists of two magnetic layers of first magnetization fixed-bed 13a and second magnetization fixed-bed 13b. And between two magnetic layers 13a and 13b, the conductor layer 14 which these magnetic layers 13a and 13b combine in antiferromagnetism is arranged. As an ingredient of this conductor layer 14, Ru (ruthenium), Cu (copper), Cr (chromium), Au(gold), Ag (silver), etc. can be used, for example.
[0020] Moreover, second magnetization fixed-bed 13b is prepared so that the lower part side may touch the antiferromagnetic substance 15, and second magnetization fixed-bed 13b will have the magnetic anisotropy of a strong one direction by the exchange interaction committed among these layers. As an ingredient of the antiferromagnetic substance 15, Mn (manganese) alloy, Co(es), nickel oxides, etc., such as Fe, nickel, Pt (platinum), Ir (iridium), and Rh (rhodium), can be used, for example.
[0021] Under the antiferromagnetic substance 15, it has the duplex substrate layer 16 which consists of Co and Si.
[0022] Thus, in the storage element 10 of the constituted TMR type, the tunnel current change by the magneto-resistive effect will be detected, and information will be read. However, it will depend for the effectiveness in the relative magnetization direction of the information storage layer 11 and the magnetization fixed bed 13.
[0023] In addition, each class (conductor a magnetic film and film) 11, 13-16 mentioned above is mainly formed by the well-known sputtering method, and should just form the tunnel barrier layer

12 by oxidizing or nitriding the metal membrane formed by sputtering.
[0024] In MRAM equipped with the storage element 10 above TMR type, since the storage element is arranged to the crossover field of the WORD write-in line 20 and the bit write-in line 30, information is alternatively written in each storage element 10 by using these two write-in lines 20 and 30 using an asteroid flux reversal property.
[0025] At this time, the synthetic magnetization in the single storage element 10 is decided by vector composition with the field HEA of easy shaft orientations and the field HHA of difficult shaft orientations which were impressed to it. The write-in current which flows the bit write-in line 30 impresses the field HEA of easy shaft orientations to a storage element 10, and the current which flows the WORD write-in line 20 impresses the field HHA of difficult shaft orientations to a storage element 10.
[0026] Drawing 5 is the asteroid Fig. showing an example of a field response of the storage element in MRAM. The asteroid curve in drawing shows the reversal threshold of the magnetization direction of the information storage layer 11 by Field HEA and Field HHA which were impressed. That is, generating of the synthetic magnetic field vector equivalent to the exterior of an asteroid curve produces field reversal in a storage element 10. However, the synthetic magnetic field vector inside an asteroid does not reverse the field of a storage element 10 from one side of the current bistability condition. Moreover, the storage element 10 located in addition to the crossing of the WORD write-in line 20 which is passing the current, and the bit write-in line 30 is also received. When the magnitude of the field is beyond the one direction reversal field HK, in order to impress the field which each write-in line 20 and 30 generates independently, and to also reverse the magnetization direction of storage elements 10 other than a crossover field, Only when a synthetic field is equivalent to the exterior (shadow part in drawing) of an asteroid curve also from this, the information writing to the selected storage element 10 is attained.
[0027] [Gestalt of the 1st operation] Next, the focus of MRAM (magnetic memory apparatus) in the gestalt of operation of the 1st of this invention is explained. Drawing 6 is the mimetic diagram showing the configuration of the characteristic important section of an example of the magnetic memory apparatus concerning this invention.
[0028] nonmagnetic [MRAM / conventional / in a WORD write-in line and a bit write-in line /, such as Cu and aluminum,] generally -- it is formed only from the conductor.
[0029] on the other hand, nonmagnetic [which each write-in lines 20 and 30 which, as for MRAM explained with this operation gestalt, sandwich a storage element 10 from the upper and lower sides as shown in drawing 6 all become from conductive matter, such as Cu, aluminum, or these alloys,] -- conductors 21 and 31 and magnetism with high permeability -- conductors 22 and 32 -- since -- it has the becoming composite construction.
[0030] magnetism -- what is necessary is just to use the alloy which makes nickel, Fe, Co, or these a principal component, for example as an ingredient of conductors 22 and 32 It is possible to specifically use the nickel-Fe alloy (iron nickel alloy) called a permalloy.
[0031] Moreover, as for each write-in lines 20 and 30, the cross section is formed for all in the shape of an abbreviation rectangle. and the magnetism of an abbreviation U shape the third page except the field by the side of a storage element 10 -- it covers to conductors 22 and 32 -- having -- **** -- the field by the side of a storage element 10 -- nonmagnetic -- conductors 21 and 31 are exposed. therefore -- each write-in line 20 and 30 comrades -- nonmagnetic -- the exposure of conductors 21 and 31 -- facing each other -- **** -- moreover, magnetism -- it is allotted so that the part of conductors 22 and 32 may become symmetrical mutually. furthermore, each write-in lines 20 and 30 -- setting -- nonmagnetic -- the cross-section width of face (refer to the inside A of drawing and B) of the part exposed to the storage element 10 side of conductors 21 and 31 is formed in the magnitude more than the component width of face (refer to the inside a of drawing, and b) of a storage element 10.
[0032] What is necessary is just to form them in it, as each above write-in lines 20 and 30 are described below. the bit write-in line 30 located above a storage element 10 -- the former -- the same

-- nonmagnetic -- plating after forming the part of a conductor 31 etc. -- magnetism -- it is possible to form by forming the part of a conductor 32. plating after forming a trench (grooving) into a membrane formation process on the other hand, for example about the WORD write-in line 20 located under the storage element 10 etc. -- the pars basilaris ossis occipitalis and lateral portion of the trench -- magnetism -- a conductor 22 -- forming membranes -- further -- the trench -- nonmagnetic -- it is possible to form by burying with a conductor 21.

[0033] MRAM [in / by using the write-in lines 20 and 30 of such a configuration / this operation gestalt] -- the magnetism of the composite constructions -- the magnetism in which the line of magnetic force conventionally distributed over the perimeter of a write-in line has high permeability since magnetic flux penetrates in the part of conductors 22 and 32 -- it converges with conductors 22 and 32 -- having -- nonmagnetic -- it concentrates on the part which conductors 21 and 31 have exposed, i.e., the part of a storage element 10, and comes to generate.

[0034] Drawing 7 is the explanatory view showing the example of the simulation result of the generating line of magnetic force in write-in line 1 duty. it is shown in drawing 7 (a) -- as -- abbreviation rectangle-like perimeter Mikata -- magnetism -- the condition of having been distributed over the perimeter at homogeneity even if it gave the write-in current when it covered with conductors 22 and 32 -- line of magnetic force -- not generating -- the magnetism -- magnetic-flux transparency with conductors 22 and 32 -- nonmagnetic -- it turns out that it concentrates on the part of conductors 21 and 31, and line of magnetic force is generated. if the current which is 1mA is specifically passed when the width of face and thickness of the write-in lines 20 and 30 are 0.25 micrometers, respectively according to numerical simulation -- nonmagnetic -- the magnitude of the field generated into the central part of the storage element 10 facing conductors 21 and 31 serves as about 15 Oe(s).

[0035] on the other hand, it is shown in drawing 7 (b) -- as -- nonmagnetic -- since line of magnetic force is distributed over the perimeter at homogeneity when it writes in only with a conductor and a line is constituted, even if it passes a 1mA current on the write-in line of width of face of 0.25 micrometers, and thickness, in the central part of a storage element 10, only the field of the magnitude of about 5 Oe extent is acquired.

[0036] Therefore, if the write-in lines 20 and 30 of a composite construction explained with this operation gestalt are used, since a write-in field can be generated more efficiently (when line of magnetic force is distributed over homogeneity) than before, it may come to reverse the magnetization direction of a storage element 10 with the current smaller than before as a result.

[0037] the magnetism covered on the write-in lines 20 and 30 in order to acquire such effectiveness efficiently -- it is desirable to make the permeability of conductors 22 and 32 or more into ten in general. moreover, magnetism -- as for the covering thickness of conductors 22 and 32, it is checked that the effectiveness of 0.01 micrometers or more, then the increment in a generating field is acquired.

[0038] moreover, abbreviation rectangle-like perimeter Mikata -- magnetism -- the magnetism of an abbreviation U shape when it covers with conductors 22 and 32 -- much line of magnetic force focuses on an inside [points / of conductors 22 and 32 / both] part (nonmagnetic part of conductors 21 and 31). therefore, nonmagnetic -- if the cross-section width of face A and B of conductors 21 and 31 is formed in the magnitude more than the component width of face a and b of a storage element 10 -- magnetism -- since the information storage layer 11 will be arranged in the form inserted into both the point rather than spacing of both the points of conductors 22 and 32 by the width of face of the information storage layer 11 of a storage element 10 becoming short, the line of magnetic force generated intensively can be efficiently impressed to the information storage layer 11.

[0039] [Gestalt of the 2nd operation] Next, the focus of MRAM (magnetic memory apparatus) in the gestalt of operation of the 2nd of this invention is explained. Drawing 8 is the mimetic diagram showing the configuration of the characteristic important section of other examples of the magnetic memory apparatus concerning this invention.

[0040] MRAM explained with this operation gestalt -- also setting -- the case of the gestalt of the 1st operation -- the same -- each write-in lines 20 and 30 -- nonmagnetic -- conductors 21 and 31 and magnetism -- it has the composite construction which consists of conductors 22 and 32. Moreover, as for each write-in lines 20 and 30, the cross section is formed for all in the shape of an abbreviation rectangle.
[0041] however, the field which counters the field by the side of the storage element 10 of each write-in lines 20 and 30 in MRAM of this operation gestalt unlike the case of the gestalt of the 1st operation as shown in drawing 8 -- magnetism -- it is covered by conductors 22 and 32. therefore, the both-sides side which stands in a row in the field by the side of a storage element 10, and this -- each -- nonmagnetic -- conductors 21 and 31 are exposed.
[0042] What is necessary is just to form them in it, as each above write-in lines 20 and 30 are described below. nonmagnetic [which consists of Cu, aluminum, or these alloys, for example about the bit write-in line 30 located above a storage element 10] -- the magnetism which forms a conductor 31 with a sputtering system or CVD (Chemical Vapor Deposition) equipment, and subsequently consists of a permalloy with a sputtering system -- a conductor 32 is formed and it is possible to form by considering as a desired pattern by ion milling or reactive ion etching after that. the WORD write-in line 20 located under the storage element 10 on the other hand -- the bit write-in line 30 -- reverse -- magnetism -- a conductor 22 and nonmagnetic -- it is possible to form in order of a conductor 21. however, nonmagnetic -- conductors 21 and 31 and magnetism -- membrane formation of conductors 22 and 32 may apply approaches other than ****, for example, plating.
[0043] using the write-in lines 20 and 30 of such a configuration -- MRAM of this operation gestalt -- also setting -- the case of the gestalt of the 1st operation -- the same -- the magnetism of the composite constructions, since magnetic flux penetrates in the part of conductors 22 and 32 the magnetism in which the line of magnetic force conventionally distributed over the perimeter of a write-in line has high permeability -- it converges with conductors 22 and 32 -- having -- nonmagnetic -- it concentrates on the part which conductors 21 and 31 have exposed, and comes to generate. Therefore, if the write-in lines 20 and 30 of a composite construction explained with this operation gestalt are used, since a write-in field can be generated more efficiently (when line of magnetic force is distributed over homogeneity) than before, it may come to reverse the magnetization direction of a storage element 10 with the current smaller than before as a result.
[0044] moreover, MRAM of this operation gestalt -- setting -- magnetism -- since conductors 22 and 32 have covered only the field which counters a storage element 10, i.e., the whole surface, the degree which line of magnetic force concentrates compared with the case of the gestalt of the 1st operation is low, but since covering of the both-sides side of the write-in lines 20 and 30 is unnecessary, it excels in the ease on manufacture. that is, the production process of the conventional MRAM -- magnetism -- only by carrying out the two-times addition of the membrane formation step of conductors 22 and 32, it writes in conventionally, reduction of a current can be aimed at, and implementation will become easy very much.
[0045] in addition -- the gestalt of the 1st mentioned above and the 2nd operation -- the both sides of the WORD write-in line 20 and the bit write-in line 30 -- nonmagnetic -- conductors 21 and 31 and magnetism -- although the case where it had the composite construction which consists of conductors 22 and 32 was mentioned as the example and explained, this invention is not limited to this. That is, it writes in, even if it is that case, and reduction of a current is [that at least one side should just have the composite construction] possible.
[0046] moreover -- the gestalt of the 1st and the 2nd operation -- perimeter Mikata of the write-in lines 20 and 30 -- magnetism -- an opposed face with the storage element 10 of the lines 20 and 30 write-in when it covers with conductors 22 and 32 -- magnetism -- although the case where it covered with conductors 22 and 32 was mentioned as the example, respectively and was explained, this invention is not limited to this. for example, the both-sides side of a write-in abbreviation rectangle-like line -- magnetism -- even if it is the case where it covers with conductors 22 and 32 -- the magnetism -- conductors 22 and 32 -- magnetic flux -- penetrating -- nonmagnetic -- since it

concentrates on the part of conductors 21 and 31 and line of magnetic force is generated, reduction of a write-in current can be aimed at.

[0047] Furthermore, although the gestalt of the 1st and the 2nd operation explained the case where a storage element 10 was a thing using a TMR ingredient, and the GMR ingredient was used, of course, it is applicable to a case completely similarly.

[0048]

[Effect of the Invention] it explained above -- as -- the magnetic memory apparatus of this invention -- a write-in line -- nonmagnetic -- a conductor and magnetism -- the case where a current is given to a write-in line by considering as the composite construction which consists of a conductor -- nonmagnetic -- since it concentrates on the part of a conductor and line of magnetic force comes to be generated, the information writing to a storage element is attained with a write-in current smaller than before. Therefore, since reduction of a write-in current can be aimed at without making coercive force of a storage element small, it writes in as a result and implementation of the improvement in dependability by low-power-izing of detailed-izing (densification) of the magnetic memory apparatus by contraction of a line drive circuit etc. and a magnetic memory apparatus and reduction of electron migration fracture of a write-in line etc. becomes easy.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the magnetic memory apparatus used as a memory device for memorizing information.

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PRIOR ART

[Description of the Prior Art] In recent years, much more high performance-ization of high integration, improvement in the speed, low electrification, etc. is requested from a device called the memory and logic which constitute this with the fast spread of personal small devices, such as information communication equipment, especially personal digital assistant equipment. Especially the high density and large capacity-ization of nonvolatile memory are becoming still more important as a technique in which a miniaturization essentially replaces a difficult hard disk drive unit and a difficult optical disk unit by existence for moving part (for example, a head seeking device and a disk rolling mechanism).
[0003] The flash memory using the semi-conductor as nonvolatile memory, FeRAM (Ferro electric Random Access Memory) using a ferroelectric, etc. are known widely. However, informational drawing speed is the order of mu second, and a flash memory has the fault that it is late compared with volatile memory, such as DRAM (Dynamic Random Access Memory) and SRAM (Static Random Access Memory). On the other hand, the problem that there are few rewritable counts is pointed out in FeRAM.
[0004] The magnetic memory apparatus called MRAM (Magnetic Random Access Memory) is observed as nonvolatile memory which does not have these faults (for example, Wang et al., IEEE Trans.Magn.33 (1997), 4498 reference). MRAM performs information storage using the storage element of a giant magneto-resistance (Giant Magnetoresistive;GMR) mold or a tunnel magneto-resistive effect (Tunnel Magnetoresistive;TMR) mold, and attracts attention increasingly by improvement in a property of a TMR ingredient in recent years especially.
[0005] In detail, in order to record information on the specific component of the elements, it has the WORD write-in line and the bit write-in line which cross the elements in all directions, and while have the storage element of the magneto-resistive effect mold arranged in the shape of a matrix, it consists of MRAM(s) so that information may be alternatively write only in the component locate in the crossover field using an asteroid property (for example, refer to publication number 10 1 116490 official report). Since MRAM of such a configuration has simple structure, high integration is easy, and a rewritable count is size in order for rotation of the magnetic moment in a magneto-resistive effect mold storage element to perform information storage. Furthermore, it is expected that it is very high-speed also about the access time, and it is checked that it can already operate on a nanosecond base.

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EFFECT OF THE INVENTION

[Effect of the Invention] it explained above -- as -- the magnetic memory apparatus of this invention -- a write-in line -- nonmagnetic -- a conductor and magnetism -- the case where a current is given to a write-in line by considering as the composite construction which consists of a conductor -- nonmagnetic -- since it concentrates on the part of a conductor and line of magnetic force comes to be generated, the information writing to a storage element is attained with a write-in current smaller than before. Therefore, since reduction of a write-in current can be aimed at without making coercive force of a storage element small, it writes in as a result and implementation of the improvement in dependability by low-power-izing of detailed-izing (densification) of the magnetic memory apparatus by contraction of a line drive circuit etc. and a magnetic memory apparatus and reduction of electron migration fracture of a write-in line etc. becomes easy.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, in MRAM, the magnitude of the write-in current at the time of storing information in a storage element poses a problem. That is, although the magnetization direction of a storage element is reversed by the current field which a WORD write-in line and a bit write-in line generate in case information is stored in a storage element, a write-in big current may be then necessary with hindrance, such as detailed-izing (densification) and low-power-izing.
[0007] nonmagnetic [of the shape of a thin film specifically used usually with semi-conductors / MRAM / conventional / line / a WORD write-in line and / bit write-in /, such as Cu (copper) and aluminum (aluminum),] -- although formed only from a conductor, if coercive force tends to write in the storage element of 20Oe(s) when those line breadth is 0.25 micrometers, for example, it is necessary to write in the big current of about 2mA, and to pass on a line furthermore, the case of for example, a write-in line where a cross-section configuration is an abbreviation rectangle -- the thickness -- line breadth and abbreviation -- the current density in that case will become the same with 3.2x106 A/cm2, and it will become close to the open-circuit threshold value by electron migration.
[0008] To such the present condition, decreasing a write-in current is also considered by making coercive force of a storage element small, for example. However, when coercive force of a storage element is made small, the magnetization direction in a storage element is reversed with the magnetic turbulence from the outside, and there is a possibility of causing the dependability fall as a memory device.
[0009] Then, even if this invention does not make coercive force of a storage element small, it aims at offering the magnetic memory apparatus whose information storage in a write-in current smaller than before becomes possible.

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MEANS

[Means for Solving the Problem] the magnetic memory apparatus constituted so that the magnetization direction of said storage element may reverse by the current field which was allotted by this invention having been thought out in order to attain the above-mentioned purpose, and approaching the storage element of a magneto-resistive effect mold, and this storage element, and which writes in, and is equipped with a line and said write-in line generates -- setting -- said write-in line -- nonmagnetic -- magnetism with a conductor and high permeability -- it is characterized by to have the composite construction which consists of a conductor.
[0011] according to the magnetic memory apparatus of the above-mentioned configuration -- the magnetism of the composite constructions of a write-in line -- the condition of having been distributed over the perimeter at homogeneity when the current was given to the write-in line, since magnetic flux penetrated in the part of a conductor -- line of magnetic force -- not generating -- magnetism -- nonmagnetic [which is not a conductor] -- it concentrates on the part of a conductor and line of magnetic force is generated. Therefore, if it is made to reverse the magnetization direction of a storage element with the concentrated line of magnetic force, the magnetization direction can be reversed with a current smaller than the case where line of magnetic force is distributed over homogeneity.
[0012]
[Embodiment of the Invention] Hereafter, the magnetic memory apparatus which starts this invention based on a drawing is explained.
[0013] [Outline of a magnetic memory apparatus] The outline configuration of the magnetic whole memory apparatus concerning this invention is explained first. Drawing 1 is the mimetic diagram showing the fundamental example of a configuration of the magnetic memory apparatus called MRAM. MRAM is equipped with the storage element 10 of two or more magneto-resistive effect molds arranged in the shape of a matrix. Furthermore, the WORD write-in line 20 and the bit write-in line 30 which cross mutually are formed so that each storage element 10 group may be crossed in all directions, so that it may correspond to each of the line on which these storage elements 10 were arranged, and a train. And each is arranged so that each storage element 10 may be in the condition inserted into the WORD write-in line 20 and the bit write-in line 30 from the upper and lower sides and it may be located in these crossover fields.
[0014] Drawing 2 is the mimetic diagram showing the outline configuration of MRAM in a detail further. although it is allotted in MRAM so that the WORD write-in line 20 and the bit write-in line 30 (only henceforth [these are named generically and] "a write-in line") may cross storage element 10 group in all directions -- the crossover field of the lines 20 and 30 write-in [these] -- a storage element 10 -- in addition, the field-effect transistor 40 which connects with each storage element 10 according to an individual is formed. And corresponding to the field-effect transistor 40 of each train, the sense amplifier 52 linked to a sense line 51 and this is formed, and the information memorized by these at the storage element 10 is detected.
[0015] Then, the configuration of each storage element part in MRAM of such a configuration is

explained. Drawing 3 is the mimetic diagram showing an example of the cross-section configuration of a single storage element part. In each storage element part, the field-effect transistor 40 which consists of the gate field 42, a source field 43, and a drain field 44 is arranged on the semi-conductor substrate 41, and the WORD write-in line 20, the storage element 10, and the bit write-in line 30 are further arranged in the upper part in order. The storage element 10 is arranged at the crossing of the WORD write-in line 20 and the bit write-in line 30 so that it may be inserted into these write-in lines 20 and 30 from the upper and lower sides, so that clearly also from this.

[0016] Here, the configuration of storage element 10 the very thing is explained. Although there are a thing using a GMR ingredient and a thing using a TMR ingredient as a storage element 10 in MRAM, a TMR type thing is mentioned as an example and explained here.

[0017] Drawing 4 is the mimetic diagram showing an example of the cross-section configuration of the magneto-resistive effect film used as a TMR type storage element. With the TMR type storage element 10, it consists of the magnetic substance, such as nickel (nickel), Fe (iron), Co(es) (cobalt), or these alloys, for example, and has the information storage layer 11 which the magnetization direction rotates comparatively easily, and information is written in by changing the magnetization direction of the information storage layer 11 by the current field which the write-in lines 20 and 30 generate (record).

[0018] Under the information storage layer 11, it has the tunnel barrier layer 12 by the insulator which consists of an oxidizing zone or nitrated cases, such as aluminum (aluminum), Mg (magnesium), and Si (silicon), etc., and while cutting magnetic association with the information storage layer 11 and the magnetization fixed bed 13 mentioned later, the role for passing tunnel current is borne.

[0019] Under the tunnel barrier layer 12, it has the magnetization fixed bed 13. The magnetization fixed bed 13 consists of two magnetic layers of first magnetization fixed-bed 13a and second magnetization fixed-bed 13b. And between two magnetic layers 13a and 13b, the conductor layer 14 which these magnetic layers 13a and 13b combine in antiferromagnetism is arranged. As an ingredient of this conductor layer 14, Ru (ruthenium), Cu (copper), Cr (chromium), Au(gold), Ag (silver), etc. can be used, for example.

[0020] Moreover, second magnetization fixed-bed 13b is prepared so that the lower part side may touch the antiferromagnetic substance 15, and second magnetization fixed-bed 13b will have the magnetic anisotropy of a strong one direction by the exchange interaction committed among these layers. As an ingredient of the antiferromagnetic substance 15, Mn (manganese) alloy, Co(es), nickel oxides, etc., such as Fe, nickel, Pt (platinum), Ir (iridium), and Rh (rhodium), can be used, for example.

[0021] Under the antiferromagnetic substance 15, it has the duplex substrate layer 16 which consists of Co and Si.

[0022] Thus, in the storage element 10 of the constituted TMR type, the tunnel current change by the magneto-resistive effect will be detected, and information will be read. However, it will depend for the effectiveness in the relative magnetization direction of the information storage layer 11 and the magnetization fixed bed 13.

[0023] In addition, each class (conductor a magnetic film and film) 11, 13-16 mentioned above is mainly formed by the well-known sputtering method, and should just form the tunnel barrier layer 12 by oxidizing or nitriding the metal membrane formed by sputtering.

[0024] In MRAM equipped with the storage element 10 above TMR type, since the storage element is arranged to the crossover field of the WORD write-in line 20 and the bit write-in line 30, information is alternatively written in each storage element 10 by using these two write-in lines 20 and 30 using an asteroid flux reversal property.

[0025] At this time, the synthetic magnetization in the single storage element 10 is decided by vector composition with the field HEA of easy shaft orientations and the field HHA of difficult shaft orientations which were impressed to it. The write-in current which flows the bit write-in line 30 impresses the field HEA of easy shaft orientations to a storage element 10, and the current which

flows the WORD write-in line 20 impresses the field HHA of difficult shaft orientations to a storage element 10.
[0026] Drawing 5 is the asteroid Fig. showing an example of a field response of the storage element in MRAM. The asteroid curve in drawing shows the reversal threshold of the magnetization direction of the information storage layer 11 by Field HEA and Field HHA which were impressed. That is, generating of the synthetic magnetic field vector equivalent to the exterior of an asteroid curve produces field reversal in a storage element 10. However, the synthetic magnetic field vector inside an asteroid does not reverse the field of a storage element 10 from one side of the current bistability condition. Moreover, the storage element 10 located in addition to the crossing of the WORD write-in line 20 which is passing the current, and the bit write-in line 30 is also received. When the magnitude of the field is beyond the one direction reversal field HK, in order to impress the field which each write-in line 20 and 30 generates independently, and to also reverse the magnetization direction of storage elements 10 other than a crossover field, Only when a synthetic field is equivalent to the exterior (shadow part in drawing) of an asteroid curve also from this, the information writing to the selected storage element 10 is attained.
[0027] [Gestalt of the 1st operation] Next, the focus of MRAM (magnetic memory apparatus) in the gestalt of operation of the 1st of this invention is explained. Drawing 6 is the mimetic diagram showing the configuration of the characteristic important section of an example of the magnetic memory apparatus concerning this invention.
[0028] nonmagnetic [MRAM / conventional / in a WORD write-in line and a bit write-in line /, such as Cu and aluminum,] generally -- it is formed only from the conductor.
[0029] on the other hand, nonmagnetic [which each write-in lines 20 and 30 which, as for MRAM explained with this operation gestalt, sandwich a storage element 10 from the upper and lower sides as shown in drawing 6 all become from conductive matter, such as Cu, aluminum, or these alloys,] -- conductors 21 and 31 and magnetism with high permeability -- conductors 22 and 32 -- since -- it has the becoming composite construction.
[0030] magnetism -- what is necessary is just to use the alloy which makes nickel, Fe, Co, or these a principal component, for example as an ingredient of conductors 22 and 32 It is possible to specifically use the nickel-Fe alloy (iron nickel alloy) called a permalloy.
[0031] Moreover, as for each write-in lines 20 and 30, the cross section is formed for all in the shape of an abbreviation rectangle. and the magnetism of an abbreviation U shape the third page except the field by the side of a storage element 10 -- it covers to conductors 22 and 32 -- having -- **** -- the field by the side of a storage element 10 -- nonmagnetic -- conductors 21 and 31 are exposed. therefore -- each write-in line 20 and 30 comrades -- nonmagnetic -- the exposure of conductors 21 and 31 -- facing each other -- **** -- moreover, magnetism -- it is allotted so that the part of conductors 22 and 32 may become symmetrical mutually. furthermore, each write-in lines 20 and 30 -- setting -- nonmagnetic -- the cross-section width of face (refer to the inside A of drawing and B) of the part exposed to the storage element 10 side of conductors 21 and 31 is formed in the magnitude more than the component width of face (refer to the inside a of drawing, and b) of a storage element 10.
[0032] What is necessary is just to form them in it, as each above write-in lines 20 and 30 are described below. the bit write-in line 30 located above a storage element 10 -- the former -- the same -- nonmagnetic -- plating after forming the part of a conductor 31 etc. -- magnetism -- it is possible to form by forming the part of a conductor 32. plating after forming a trench (grooving) into a membrane formation process on the other hand, for example about the WORD write-in line 20 located under the storage element 10 etc. -- the pars basilaris ossis occipitalis and lateral portion of the trench -- magnetism -- a conductor 22 -- forming membranes -- further -- the trench -- nonmagnetic -- it is possible to form by burying with a conductor 21.
[0033] MRAM [in / by using the write-in lines 20 and 30 of such a configuration / this operation gestalt] -- the magnetism of the composite constructions -- the magnetism in which the line of magnetic force conventionally distributed over the perimeter of a write-in line has high permeability

since magnetic flux penetrates in the part of conductors 22 and 32 -- it converges with conductors 22 and 32 -- having -- nonmagnetic -- it concentrates on the part which conductors 21 and 31 have exposed, i.e., the part of a storage element 10, and comes to generate.
[0034] Drawing 7 is the explanatory view showing the example of the simulation result of the generating line of magnetic force in write-in line 1 duty. it is shown in drawing 7 (a) -- as -- abbreviation rectangle-like perimeter Mikata -- magnetism -- the condition of having been distributed over the perimeter at homogeneity even if it gave the write-in current when it covered with conductors 22 and 32 -- line of magnetic force -- not generating -- the magnetism -- magnetic-flux transparency with conductors 22 and 32 -- nonmagnetic -- it turns out that it concentrates on the part of conductors 21 and 31, and line of magnetic force is generated. if the current which is 1mA is specifically passed when the width of face and thickness of the write-in lines 20 and 30 are 0.25 micrometers, respectively according to numerical simulation -- nonmagnetic -- the magnitude of the field generated into the central part of the storage element 10 facing conductors 21 and 31 serves as about 15 Oe(s).
[0035] on the other hand, it is shown in drawing 7 (b) -- as -- nonmagnetic -- since line of magnetic force is distributed over the perimeter at homogeneity when it writes in only with a conductor and a line is constituted, even if it passes a 1mA current on the write-in line of width of face of 0.25 micrometers, and thickness, in the central part of a storage element 10, only the field of the magnitude of about 5 Oe extent is acquired.
[0036] Therefore, if the write-in lines 20 and 30 of a composite construction explained with this operation gestalt are used, since a write-in field can be generated more efficiently (when line of magnetic force is distributed over homogeneity) than before, it may come to reverse the magnetization direction of a storage element 10 with the current smaller than before as a result.
[0037] the magnetism covered on the write-in lines 20 and 30 in order to acquire such effectiveness efficiently -- it is desirable to make the permeability of conductors 22 and 32 or more into ten in general. moreover, magnetism -- as for the covering thickness of conductors 22 and 32, it is checked that the effectiveness of 0.01 micrometers or more, then the increment in a generating field is acquired.
[0038] moreover, abbreviation rectangle-like perimeter Mikata -- magnetism -- the magnetism of an abbreviation U shape when it covers with conductors 22 and 32 -- much line of magnetic force focuses on an inside [points / of conductors 22 and 32 / both] part (nonmagnetic part of conductors 21 and 31). therefore, nonmagnetic -- if the cross-section width of face A and B of conductors 21 and 31 is formed in the magnitude more than the component width of face a and b of a storage element 10 -- magnetism -- since the information storage layer 11 will be arranged in the form inserted into both the point rather than spacing of both the points of conductors 22 and 32 by the width of face of the information storage layer 11 of a storage element 10 becoming short, the line of magnetic force generated intensively can be efficiently impressed to the information storage layer 11.
[0039] [Gestalt of the 2nd operation] Next, the focus of MRAM (magnetic memory apparatus) in the gestalt of operation of the 2nd of this invention is explained. Drawing 8 is the mimetic diagram showing the configuration of the characteristic important section of other examples of the magnetic memory apparatus concerning this invention.
[0040] MRAM explained with this operation gestalt -- also setting -- the case of the gestalt of the 1st operation -- the same -- each write-in lines 20 and 30 -- nonmagnetic -- conductors 21 and 31 and magnetism -- it has the composite construction which consists of conductors 22 and 32. Moreover, as for each write-in lines 20 and 30, the cross section is formed for all in the shape of an abbreviation rectangle.
[0041] however, the field which counters the field by the side of the storage element 10 of each write-in lines 20 and 30 in MRAM of this operation gestalt unlike the case of the gestalt of the 1st operation as shown in drawing 8 -- magnetism -- it is covered by conductors 22 and 32. therefore, the both-sides side which stands in a row in the field by the side of a storage element 10, and this --

each -- nonmagnetic -- conductors 21 and 31 are exposed.
[0042] What is necessary is just to form them in it, as each above write-in lines 20 and 30 are described below. nonmagnetic [which consists of Cu, aluminum, or these alloys, for example about the bit write-in line 30 located above a storage element 10] -- the magnetism which forms a conductor 31 with a sputtering system or CVD (Chemical Vapor Deposition) equipment, and subsequently consists of a permalloy with a sputtering system -- a conductor 32 is formed and it is possible to form by considering as a desired pattern by ion milling or reactive ion etching after that. the WORD write-in line 20 located under the storage element 10 on the other hand -- the bit write-in line 30 -- reverse -- magnetism -- a conductor 22 and nonmagnetic -- it is possible to form in order of a conductor 21. however, nonmagnetic -- conductors 21 and 31 and magnetism -- membrane formation of conductors 22 and 32 may apply approaches other than ****, for example, plating.
[0043] using the write-in lines 20 and 30 of such a configuration -- MRAM of this operation gestalt -- also setting -- the case of the gestalt of the 1st operation -- the same -- the magnetism of the composite constructions, since magnetic flux penetrates in the part of conductors 22 and 32 the magnetism in which the line of magnetic force conventionally distributed over the perimeter of a write-in line has high permeability -- it converges with conductors 22 and 32 -- having -- nonmagnetic -- it concentrates on the part which conductors 21 and 31 have exposed, and comes to generate. Therefore, if the write-in lines 20 and 30 of a composite construction explained with this operation gestalt are used, since a write-in field can be generated more efficiently (when line of magnetic force is distributed over homogeneity) than before, it may come to reverse the magnetization direction of a storage element 10 with the current smaller than before as a result.
[0044] moreover, MRAM of this operation gestalt -- setting -- magnetism -- since conductors 22 and 32 have covered only the field which counters a storage element 10, i.e., the whole surface, the degree which line of magnetic force concentrates compared with the case of the gestalt of the 1st operation is low, but since covering of the both-sides side of the write-in lines 20 and 30 is unnecessary, it excels in the ease on manufacture. that is, the production process of the conventional MRAM -- magnetism -- only by carrying out the two-times addition of the membrane formation step of conductors 22 and 32, it writes in conventionally, reduction of a current can be aimed at, and implementation will become easy very much.
[0045] in addition -- the gestalt of the 1st mentioned above and the 2nd operation -- the both sides of the WORD write-in line 20 and the bit write-in line 30 -- nonmagnetic -- conductors 21 and 31 and magnetism -- although the case where it had the composite construction which consists of conductors 22 and 32 was mentioned as the example and explained, this invention is not limited to this. That is, it writes in, even if it is that case, and reduction of a current is [that at least one side should just have the composite construction] possible.
[0046] moreover -- the gestalt of the 1st and the 2nd operation -- perimeter Mikata of the write-in lines 20 and 30 -- magnetism -- an opposed face with the storage element 10 of the lines 20 and 30 write-in when it covers with conductors 22 and 32 -- magnetism -- although the case where it covered with conductors 22 and 32 was mentioned as the example, respectively and was explained, this invention is not limited to this. for example, the both-sides side of a write-in abbreviation rectangle-like line -- magnetism -- even if it is the case where it covers with conductors 22 and 32 -- the magnetism -- conductors 22 and 32 -- magnetic flux -- penetrating -- nonmagnetic -- since it concentrates on the part of conductors 21 and 31 and line of magnetic force is generated, reduction of a write-in current can be aimed at.
[0047] Furthermore, although the gestalt of the 1st and the 2nd operation explained the case where a storage element 10 was a thing using a TMR ingredient, and the GMR ingredient was used, of course, it is applicable to a case completely similarly.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the mimetic diagram showing the fundamental example of a configuration of a magnetic memory apparatus.
[Drawing 2] It is the mimetic diagram showing an example of the outline configuration of a magnetic memory apparatus in a detail.
[Drawing 3] It is the mimetic diagram showing an example of the cross-section configuration of the single storage element part which constitutes a magnetic memory apparatus.
[Drawing 4] It is the mimetic diagram showing an example of the cross-section configuration of the magneto-resistive effect film used as a storage element of a tunnel magneto-resistive effect mold.
[Drawing 5] It is the asteroid Fig. showing an example of a field response of the storage element in a magnetic memory apparatus.
[Drawing 6] It is the mimetic diagram showing the configuration of the characteristic important section of an example of the magnetic memory apparatus concerning this invention.
[Drawing 7] It is the explanatory view showing the example of the simulation result of the generating line of magnetic force in write-in line 1 duty, and drawing showing the simulation result which (a) requires for this invention, and (b) are drawings showing the conventional simulation result.
[Drawing 8] It is the mimetic diagram showing the configuration of the characteristic important section of other examples of the magnetic memory apparatus concerning this invention.
[Description of Notations]
10 -- a storage element, a 20 -- WORD write-in line, and 21 -- nonmagnetic -- a conductor and 22 -- magnetism -- a conductor, a 30 -- bit write-in line, and 31 -- nonmagnetic -- a conductor and 32 -- magnetism -- a conductor

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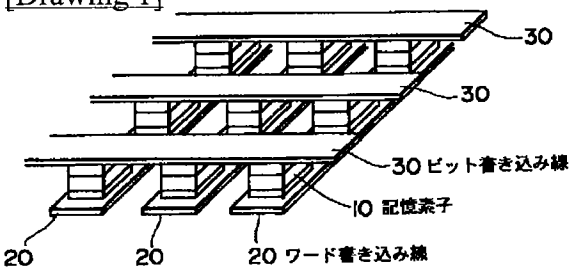
[Translation done.]

* NOTICES *

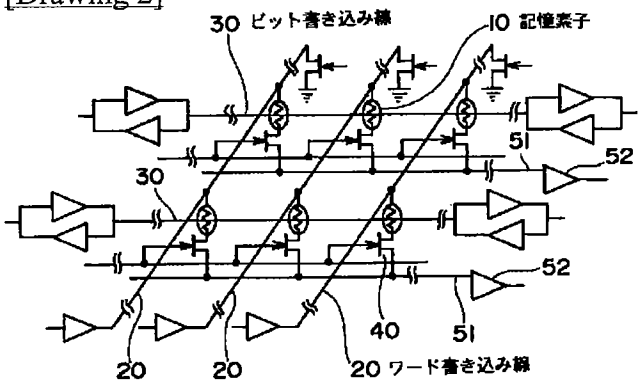
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

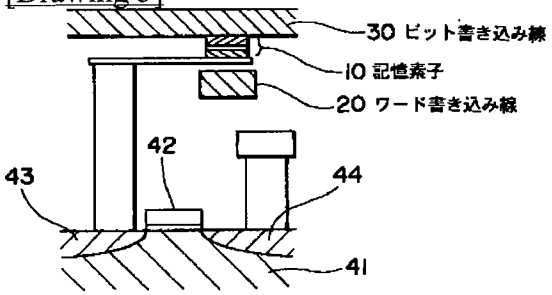
[Drawing 1]



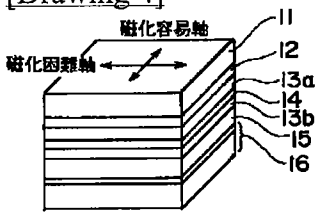
[Drawing 2]



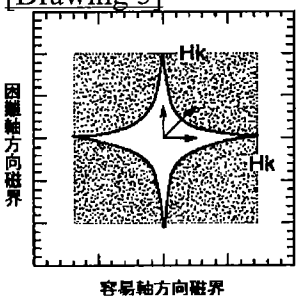
[Drawing 3]



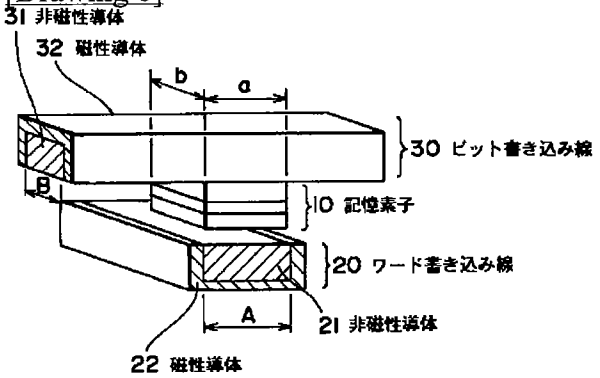
[Drawing 4]



[Drawing 5]

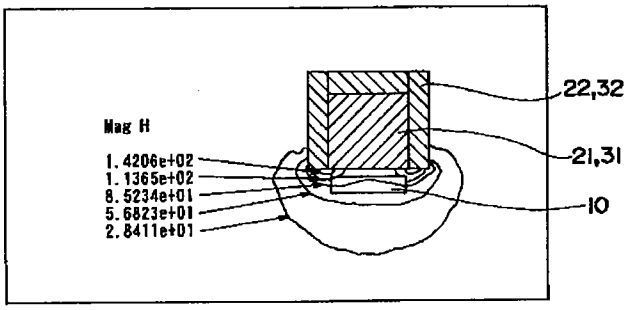


[Drawing 6]

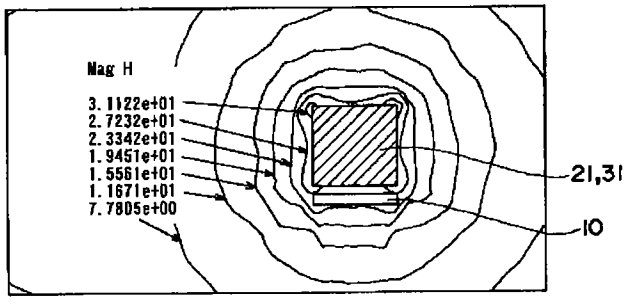


[Drawing 7]

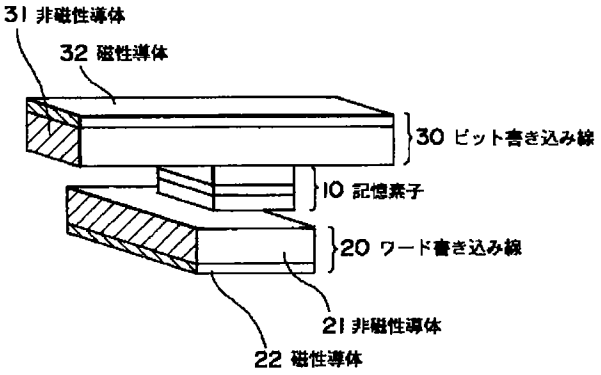
(a)



(b)



[Drawing 8]



[Translation done.]